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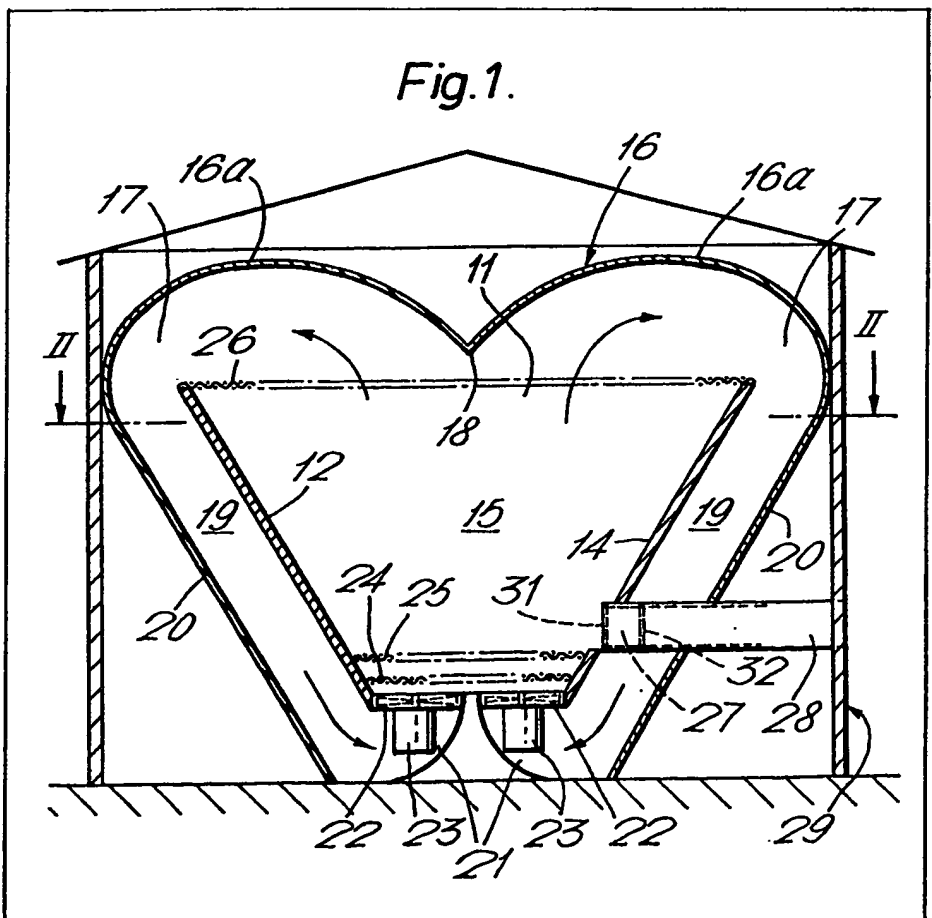
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## (54) Apparatus for simulating free-fall conditions

(57) Apparatus for simulating free-fall conditions, e.g. for training for the sport of sky-diving comprises an enclosed space (15) and a plurality of fans (23) arranged below the space to blow air upwardly therethrough at a velocity of between 150 k.p.h. and

350 k.p.h. sufficient to support a human body in the air flow. Upwardly diverging side walls (12, 14) of the space result in a velocity gradient and the roof (16) is shaped to direct the air to apertures (11) between the roof and the side walls for return through ducts (19) to the fans. Access to the space is through air-lock chambers (27)



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Fig. 1.

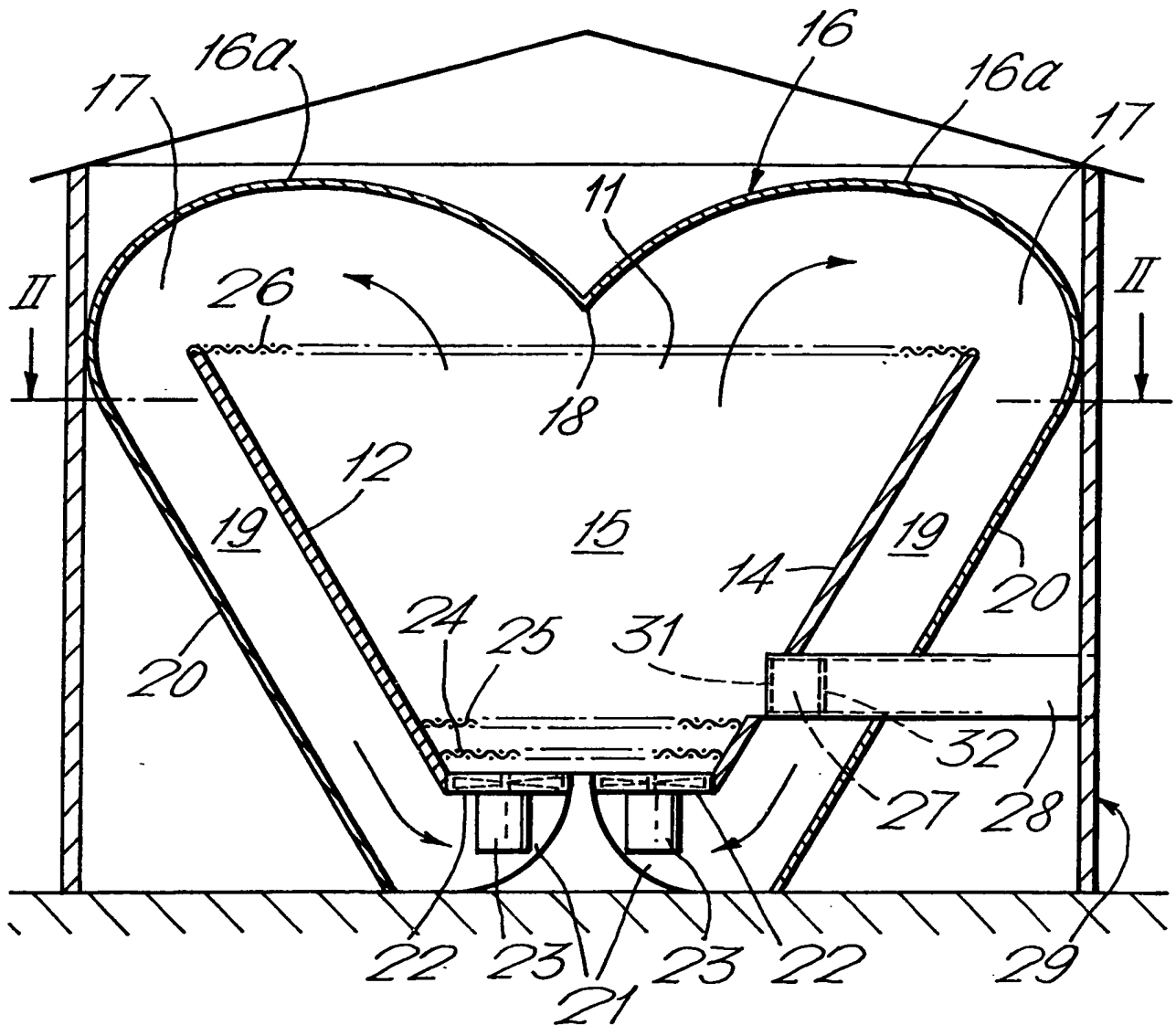
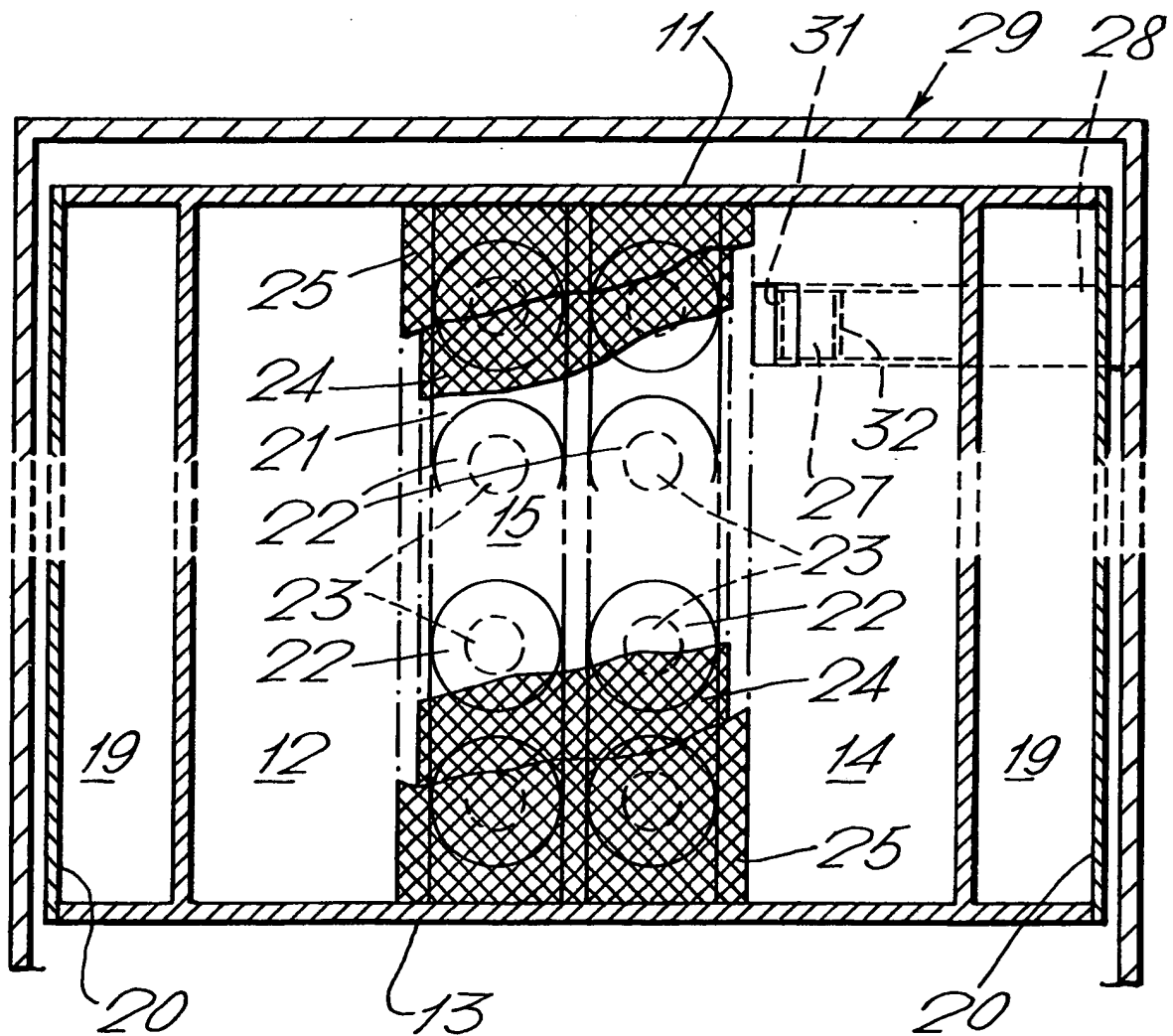


Fig. 2.



# SPECIFICATION

## Apparatus for simulating free fall conditions

The present invention relates to a machine for simulating free fall conditions such as are achieved when a body falls through the air at its terminal velocity.

At present it is possible for people to experience free fall conditions during parachute jumping before the parachute has opened, but for the majority of people this sport is too daunting to attempt in the first instance. For those who overcome their initial fears, however, free fall is a pleasurable experience and one which allows the development of a wide range of skills which differ from those associated with other sports. In particular, a great deal of muscular control and coordination is required in order to vary the attitude and orientation of the body to determine speed and direction of movement, both in a vertical and horizontal direction.

Clearly such skills are acquired only after considerable practice and a further problem associated with parachuting is that of cost; each parachute jump is in itself extremely expensive and provides a few minutes only of fall under free fall conditions, while the overall time required to effect each jump, from the initial preparations to landing, is lengthy and allows time for only two or three such jumps per day. The present invention seeks to provide apparatus by means of which it is possible to simulate free fall conditions to allow a far greater number of people to experience such conditions without the expense and fears associated with the current sport and also to give effectively unlimited time under simulated free fall to allow development of the sport.

According to the present invention there is provided apparatus for simulating free fall conditions comprising a wall structure enclosing an interior space on the sides thereof, and means for directing a stream of gas, normally air, upwardly through the space at a velocity sufficient to support a human body within this space, the body being spaced from the walls of the structure.

Apparatus formed as an embodiment of the invention thus achieves the desired effect by enclosing an upward stream of air in a relatively restricted cross-sectional area, the stream of air having sufficient velocity to support the human body against the effect of gravity. Although a person in the air stream would be stationary with respect to the ground, he would experience the same airflow conditions as if the air were stationary and he were falling through it under free fall conditions.

It is known that the terminal velocity of a body under free fall conditions can be greater than 100 mph and thus the velocity of air within the space defined by the walls of the structure must be quite considerable. The precise terminal velocity depends not only on the weight of the

arms and legs to alter his orientation with respect to the ground, thereby effectively changing his frontal cross-sectional area and reducing or increasing the drag or wind resistance.

The wall structure may enclose a space of uniform cross-section such that the upward velocity of the air in the space is substantially constant but in preferred embodiments of the invention, upwardly-divergent, opposing walls are provided so that a velocity gradient is achieved, the velocity of the air being reduced as it rises up through the space. This feature allows vertical separation of a plurality of people within the space to be achieved, some people falling effectively faster than others by being positioned lower in the space where the airspeed is greater, others being higher where the airspeed is lower. The wall structure may, for example, be frusto-conical in form but preferably has a rectangular plan for convenience and simplicity of construction, in which case only two opposing walls need diverge, the other two walls being substantially vertical. The inclination of the opposing walls may be chosen according to the air velocity gradient it is desired to achieve within the space.

The means for introducing air into the interior space defined by the walls of the structure may be constituted by a plurality of fans driven by electric or other motors, the fans being arranged in ducts having outlets in the lower part of the said two upwardly divergent side walls or being located directly beneath the enclosed space. The outlets from the fans are preferably covered by mesh for safety reasons.

Although the space enclosed by the walls may be open upwardly, such that the air is lost from the apparatus after use, it is preferred, for reasons of economy, for the structure to be covered by a roof which is shaped to direct the air outwardly from the space to apertures between the wall or walls and the roof, means being provided for returning the air downwardly to the fans for recirculation through the apparatus. Such recirculation is economical in that, in most countries, the air would need to be either heated or cooled for the comfort of the users and energy would not be wasted in bringing fresh air continuously to a suitable temperature; some fresh air must, of course, be allowed in if the air is not to become stale and deoxygenated. The means for recirculating the air are preferably such as to maintain the air flow at a substantial velocity to reduce the work required from the fans in reaccelerating it.

Access to the internal space is preferably through a wind-lock chamber having two doors or other closable ports, one between the chamber and the outside of the structure and one between the chamber and the internal space. Preferably a mechanism is provided which ensures that only one door can be open at any one time to ensure that the fast moving air in the internal space

structure.

The walls of the structure may be padded or covered by, for example, netting to help prevent users of the apparatus from injuring themselves during use.

In order to extend the usefulness of the apparatus for experimentation and training purposes, further means, such as variable speed fans, may be provided for regulating the airspeed within the space defined by the walls of the structure.

One embodiment of the present invention will now be more particularly described, by way of example, with reference to the accompanying

purely diagrammatic drawings, in which:

Figure 1 is a vertical sectional view of apparatus according to the invention, and

Figure 2 is a cross-sectional view taken on the line II—II of Figure 1.

Referring now to the drawings, the apparatus for simulating free fall conditions comprises a generally rectangular-plan wall structure including four upright side walls 11, 12, 13, 14, two opposite longer walls 12, 14 of which are inclined to the vertical so as to diverge from one another upwardly, and the shorter walls 11 and 13 of which are substantially vertical, the walls 11—14 enclosing a space 15.

A ceiling 16 extends over the space 15 and outwardly of the longer walls 12, 14 and is spaced from the upper edges of the walls 12, 14 by gaps 17. The ceiling 16 is formed with two arcuate sections 16a, concavely curved with respect to the space 15 and meeting at a longitudinal central ridge 18, so as to direct air flowing upwardly through the space 15 outwardly and downwardly into channels 19 between the outer faces of the walls 12, 14 and outer walls 20.

The walls 20 may comprise the vertical walls of a building 29 enclosing the apparatus but in this embodiment they comprise additional walls within the building 29, each wall being substantially parallel to the adjacent wall 12 or 14. The building 29 may be an existing building or purpose built and serves to support (supporting structures not shown) and protect the walls 11—14 and ceiling 16 and also houses changing rooms and other facilities outside the wall structure.

The channels 19 open at their lower ends into respective chambers 21 beneath the space 15 in each of which a number of large fans 22 driven by motors 23, which may be electric motors or driven by any other source of motive power, are housed. The fans 22 are so located and so driven as to impel air at a high velocity upwardly into the space 15.

The fans 22 have their own protective housings but, in addition, a rigid mesh floor 24 is provided across the lower part of the space 15 to prevent any persons in the space 15 from falling into the fan chambers 21. A non-rigid mesh 25 is located above the mesh 24 to prevent persons in the chamber from injuring themselves should they fall,

mesh 26 is provided across the upper part of the space 15 to prevent people from being carried out of the space and into the channels 19 with the air stream.

Access to the space 15 is gained through one or more wind-lock chambers 27, located in the lower part of one of the walls 11—14 (shown in the wall 14) and having two doors 31, 32, one of which (the door 31) opens into the space 15 defined by the wall structure 11—14 and the other of which (the door 32) opens into a corridor 28 outside the wall structure and leading to changing rooms or other amenities (not shown). The two doors 31, 32 are of a type which substantially seal the door opening, when closed, to provide a wind-tight enclosure.

The doors 31, 32 are linked by a mechanism which ensures that only one door, 31 or 32 can be opened at any one time to prevent fast flowing air in the space 15 from blowing into the corridor 28.

In operation of the apparatus, the motors 23 are energised to drive the fans 22 at high speed to draw air through the channels 19 and to deliver it at a high velocity to the interior space 15. The fans 20 and motors 23 should be sufficiently large to move the required mass of air, known from the dimensions of the apparatus, at up to 200 mph as it passes the mesh 24, although for the majority of the time air speeds substantially below this, say in the region of 150 mph at the mesh 24 are adequate since this will give air speeds within the height of the space 15 over the range of terminal velocities normally encountered in true free fall conditions.

As the air stream flows up through the space 15 its velocity diminishes because of the divergence of the walls 12, 14, the velocity gradient depending on the inclination of the walls 12, 14 and the velocity of the air close to the ceiling 16, also depending on the height of the wall structure.

The ceiling 16 is shaped to divert the air stream outwardly to the channels 19 with minimum turbulence. The channels 19 are relatively narrow in order to maintain the velocity of the air stream to deliver it to the chambers 21 and back to the fans 24 for recirculation. This reduces the energy required to reaccelerate the air mass to the required velocity at the mesh 24 and hence reduces the overall running costs of the apparatus. Recirculation of air also means that little energy need be used in heating or cooling the air to a suitable temperature for use in the apparatus although fresh air is bled into the system by means not shown.

To experience free fall conditions in the apparatus, a user enters the wind-lock chamber 27 from the corridor 28 through the door 32, the door 31 being closed. On closing the door 32, he is then able to open the door 31 to gain access to the space 15. Preferably both doors 31, 32 are of a sliding, self-closing type. The user may then jump out into the space 15 where he will be

adjustment of his position (that is relative positions of arms and legs and body orientation), the user can change the horizontal level at which equilibrium conditions are reached, a smaller air resistance permitting him to sink into a lower region of the space 15 where the air speed is greater.

Since a user can generate rather high lateral speeds in use of the apparatus, it is considered advisable for the inner surface of the walls 11—14 to be provided with some form of protective material such as padding or netting, to prevent damage on impact if a beginner should lose control in the early stages of training. Once experience has been gained, of course, a user can control his lateral position with quite a high degree of accuracy and such impact should not occur.

Simulated free fall conditions can be experienced more or less indefinitely, the user gaining experience and having time to practise manoeuvres and movements for which all too little time is available in true free fall conditions. Moreover, for the purpose of training or experimentation the motors 23 can be controlled to regulate the air speed to a higher or lower value, and asymmetrical upward air flows can be generated to simulate mass air movements by running the motors at one end or side of the apparatus faster than the others. At very low speeds of the motors 23 the apparatus may also be used for testing parachutes since equilibrium conditions can be established.

#### CLAIMS

1. Apparatus for simulating free fall conditions comprising an upstanding wall structure enclosing an interior space, a port for human access to the space and means for producing and directing a stream of air upwardly through the space at a velocity such that the air stream can support a human body in a floating condition within the space, the body being spaced from the walls of the structure.

2. Apparatus as claimed in Claim 1, in which opposing internal surfaces of the wall structure diverge upwardly.

3. Apparatus as claimed in Claim 2, in which the space is substantially rectangular in horizontal section and is defined by upwardly-diverging side walls interconnected by substantially vertical end walls.

4. Apparatus as claimed in any of the preceding

claims, in which the space is covered by a roof shaped to direct the upward air flow from the top of the space into an aperture or apertures between the roof and the wall structure.

5. Apparatus as claimed in Claim 4, in which each aperture communicates with a duct arranged to return air to the means for producing the air stream.

6. Apparatus as claimed in Claim 5 as dependent on Claim 3, in which the roof is shaped to direct the air flow to apertures between the roof and each of the upwardly diverging walls and th ducts extend between the outer surface of each said wall and a respective substantially parallel wall.

7. Apparatus as claimed in any of the preceding claims, in which the means for producing the air stream comprise at least one fan located beneath the said space.

8. Apparatus as claimed in Claim 7, in which there are a plurality of fans each arranged to direct air upwardly into the said interior space and each housed in a respective chamber arranged to receive air from an air-return duct.

9. Apparatus as claimed in Claim 7, in which the or each fan can deliver air at a velocity of the order of 150 km/hour and up to a velocity of the order of 350 km/hour into the said space.

10. Apparatus as claimed in Claim 7, Claim 8 or Claim 9, in which the or each fan is separated from the space by a mesh arranged to prevent any person using the space from contacting the fan.

11. Apparatus according to any preceding claim in which the upper and lower ends of the space are closed by flexible meshes.

12. Apparatus according to any preceding claim, in which the interior surfaces of the wall structure are covered by padding or flexible mesh to protect users of the apparatus from injury.

13. Apparatus according to any preceding claim, in which the access port to the space comprises at least one air lock chamber having a first door between the chamber and the said space and a second door between the chamber and the external space surrounding the wall structure.

14. Apparatus according to Claim 13, in which control means are provided for preventing the doors of each air-lock chamber from being open simultaneously.

15. Apparatus for simulating free-fall conditions, substantially as herein described with reference to, and as shown in, the accompanying drawings.